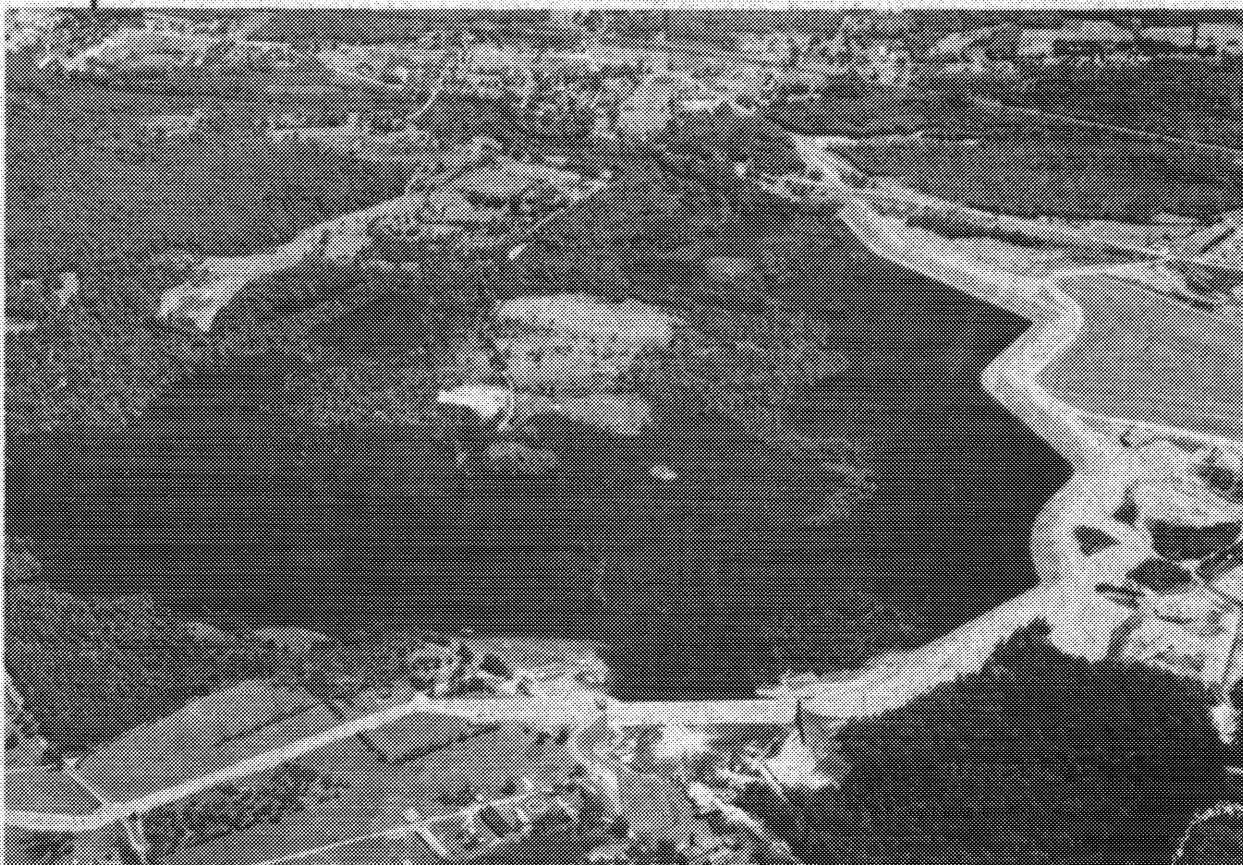
Flood Control in Connecticut



MANSFIELD HOLLOW DAM

by
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U. S. Army Engineer Division, New England
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FLOOD CONTROL IN CONNECTICUT

INTRODUCTION

The U. S. Army Engineer Division of New England, one of the Corps of Engineers' ten divisions in the United States, is now in the midst of planning and constructing the largest system of flood control works in the history of New England. The catastrophic New England floods of August and October 1955 took more than 100 lives and caused damages of over 1/2 billion dollars. Climaxing a long history of flooding, the 1955 disaster aroused a public demand for greater protection. Congress, in response to the demands, instructed the Corps of Engineers to review the flood control plans for all rivers of the Northeast and appropriated funds to begin immediate construction of a number of badly needed flood control works already authorized.

To review briefly the work accomplished by the Corps of Engineers, only 9 flood control reservoirs and 14 local protective works were constructed prior to the 1955 floods, somewhat less than 20 percent of the comprehensive program recommended by the Corps for the protection of New England. Five of these projects are located in Connecticut: the Mansfield Hollow Reservoir in the Thames River Basin and four local protection works at Hartford, East Hartford, Winsted and Norwalk. During the flood of August 1955, only those few cities and towns in southern New England defended by completed reservoirs, dikes and floodwalls escaped serious damage and loss of life. In areas which remained vulnerable to flooding, nearly 100 lives were lost, and damages totalled over $530 million. Here in Connecticut, the state by far the hardest hit, this flood left in its wake 77 dead and damages of over $370 million.

Although much remains yet to be done, remarka ble progress has been made since 1955 in controlling New England's most damaging flood-producing rivers. Under this accelerated program, the U. S. Army Engineer Division of New England has in the past five years completed a total of 15 flood control projects at a cost of $35 million. Eleven projects costing $90 million are today under construction, and five additional projects estimated to cost $42 million are now being designed. This is a total of 31 flood control projects which will be completed in the near future at a total cost of $167 million. Thus more has been done in the past five years to protect the people of New England than was accomplished in the whole previous history of the region.

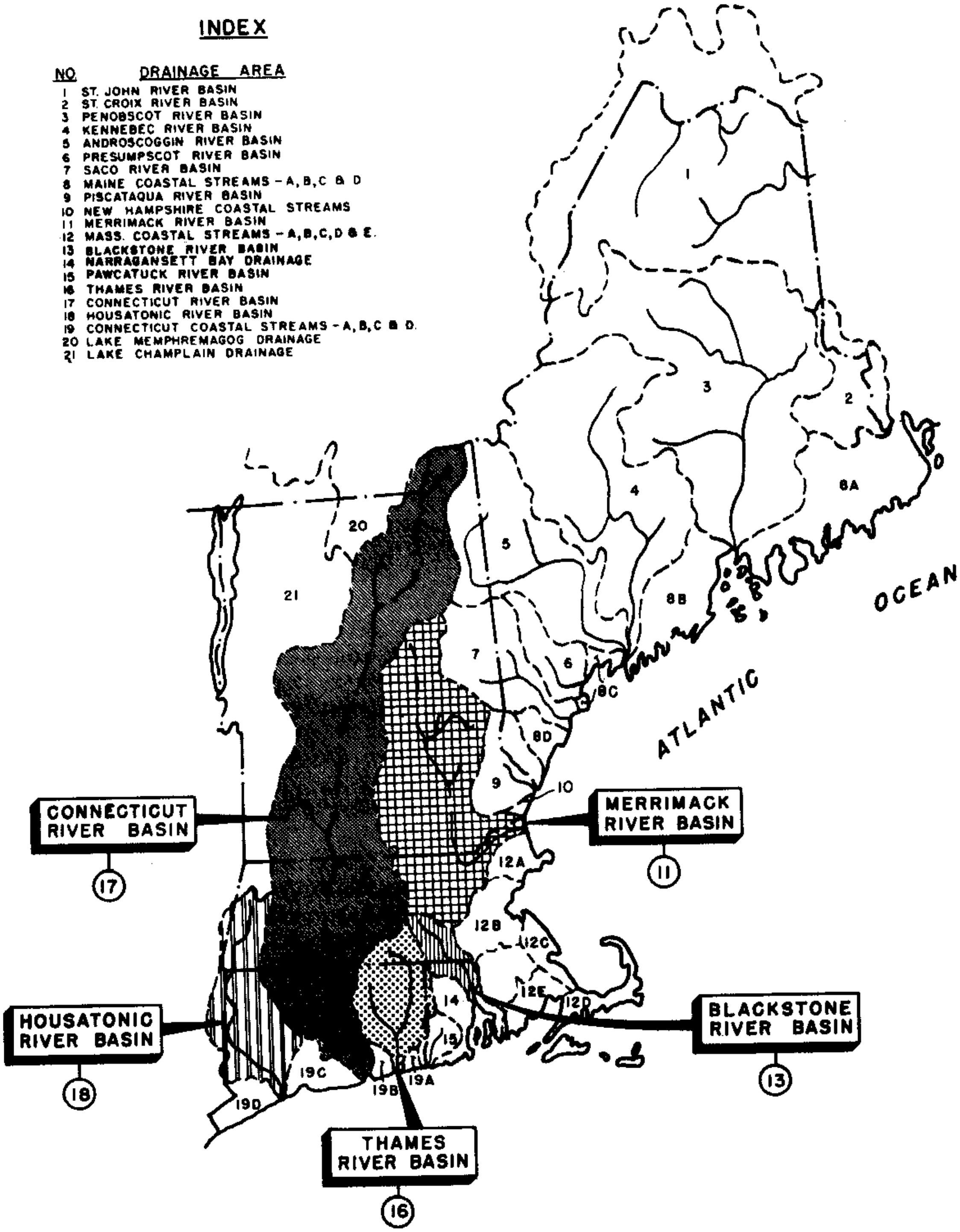
Nine of the 31 projects in this program, 4 essentially dry-bed flood control reservoirs and 5 local protective works, costing in all $34 million, are being constructed in Connecticut to operate in conjunction with the five existing projects to control the flows of the state's three major flood-producing basins: the Housatonic-Naugatuck in the west, the Connecticut which flows through the heart of the state, and Thames River Basin in the east. It is important to realize at the outset, however, that the full value to Connecticut in lives and dollars saved by the projects now under construction cannot be assessed strictly on the basis of state boundaries. The projects recently completed and now under construction in the state in the Thames and Connecticut River basins are components of comprehensive, basin-wide flood control systems encompassing other New England states. A total of 16 upstream reservoirs costing approximately $80 million in the Connecticut and Thames River basins in Vermont, New Hampshire, and Massachusetts will directly benefit communities in Connecticut. Construction of these reservoirs was made possible by the Flood Control Compacts among the several states providing for compensation of tax losses on lands taken in Vermont, New Hampshire, and Massachusetts for construction of dams and reservoirs which reduce flood flows in the Connecticut and Thames River basins in the state of Connecticut. Therefore, the system of 14 flood control reservoirs and local protective works located within the state actually represents less than half of the total number of units that will go into operation to protect the people of Connecticut from floods.

THE FLOOD PROBLEM IN NEW ENGLAND

Before discussing in greater detail the three comprehensive flood control systems of Connecticut, it may be helpful first to review briefly the nature of the flood problems in New England and the engineering methods devised to solve these problems. The need for comprehensive, integrated flood control systems containing numerous components arises from the singular economic, topographic and hydrologic characteristics of the New England region. The typical New England river basin flood exhibits certain characteristics which distinguish it from floods in other parts of the world. Whether one considers the heavily groined and revetted channel of the Oder in Germany; the wide, depressed flood plain of the Yangtze Kiang in China; or the drainage systems of the great plains and the American Southwest, one rarely encounters the peculiar combination of hydrologic and economic factors characteristic of the river basins of Northeastern United States.

Geologically, New England is a hilly, glaciated region of stony uplands cut by narrow, irregular drainage patterns of numerous small streams, lakes, and ponds. In three hundred years its industrial growth has been confined to a strip of coastline and the narrow flood plains of its drainage basins. Five of these basins are considered principal flood producers (Plate 1): the Housatonic-Naugatuck in the west, the Connecticut extending from Canada to Long Island Sound, the French-Quinebaug-Thames system debouching at New London, Connecticut, the Blackstone feeding Narragansett Bay at Providence, Rhode Island, and the Merrimack flowing through New Hampshire and northeastern Massachusetts into the Atlantic. A series of drainage basins less subject to damaging floods extends from the Androscoggin and the Kennebec in southern Maine to the valley of the St. Croix emptying into Passamaquoddy Bay at the Canadian border.

During the first two centuries of our history, New England was, and in many respects remains today, the industrial center of the United States. Forty percent of our finished brass and bronze, for example, is produced in the tiny Naugatuck Valley. And because of the rocky and hilly topography, the narrow flood plains of these five basins are today practically continuous ribbons of industrial and population concentration. Flood vulnerability has increased roughly exponentially with economic growth. Significant of this accelerating vulnerability in more than three hundred years of record is the fact that the greatest flood losses but probably not the largest floods have occurred most recently. Of the cumulative billion and a third



MAJOR FLOOD PROBLEM AREAS
NEW ENGLAND

PLATE NO. 1

dollar flood loss of record over the past 30 years, nearly fifty percent, or $530 million, was suffered in the last flood in New England. This industrial concentration in the narrow flood plains yields the first principle of New England flood control planning: direct protection of the major damage centers by construction of large dams on the main river stems is rarely justified economically.

The second principle has a similar economic basis. The tributary systems of the five major flood basins are generally steep, narrow and "flashy". These tributary valleys, set in the rugged and hilly terrain, have become densely populated along the river banks. Any adequate flood control plan must be designed to protect not only the economies of the main river valleys but those of the tributaries as well. Large structures like the John Martin and Denison Dams on the main stem of the Arkansas for example, if built on the Connecticut above Hartford would not only flood out Springfield, Massachusetts, but would afford no protection to the tributary valleys. The facts thus point to a large number of dams on the tributaries rather than to a few dams on the main river stems as part of the solution to the flood control problem in New England; but only part of the solution.

Hydro plants, the paper, textile and metals industries and municipal water supply have developed and are saturating progressively the tributary valleys with reservoirs. Suitable flood control sites combining adequate reservoir capacity with substantial watershed control are ever fewer and more costly to develop. From this dearth of reservoir sites on the tributaries, the third and fourth principles of New England flood control are evident: multiple purpose reservoirs for power and flood control are usually uneconomical; and those few tributary sites which remain suitable for flood control must be supplemented by local protection works: channel improvements, dikes, floodwalls, diversions and the like, if adequate protection of the main stream damage centers is to be achieved.

From these four principles, the problem of New England flood control design begins to take shape. In broad outline it involves an integrated flood control system for each of the five major flood basins, each system designed to be operated in time of flood as a coordinated whole. Meteorologically however, this poses a fifth and very delicate problem for the hydrologist. Though densely populated and highly developed economically, the entire area of the six New England states is smaller than a single large drainage basin in the Middle West. The Fort Peck reservoir on the Missouri, for example, would cover more than one-third of the area of the entire State of

Rhode Island. Thus the wide expanse of precipitation from tropical hurricanes to which New England is subject, usually affects not only the entire watershed of a single drainage basin but frequently several basins simultaneously. This is just what occurred in Connecticut in August 1955, when the Housatonic-Naugatuck, the Connecticut, the Thames, as well as a number of coastal streams, all reached peak flood stages within hours of each other. Under these conditions, tributary runoff is closely synchronized, each tributary contributing concurrently to flood peaks in the main channel downstream. The hydrologist's problem is thus to design a reservoir system to desynchronize simultaneous tributary contributions to the downstream flood crest and to calculate the capacities of local protective works at the main damage centers adequate to contain this reduced flood crest. This presupposes centralized control and the most delicately coordinated operation of the tributary reservoirs.

The hydrologist is further challenged by a sixth distinguishing characteristic of New England floods: they can be torrential in nature, not just floods of inundation. The steep slopes and narrow valleys, particularly under conditions of soil saturation from continued light rainfall, have somewhat the hydrological characteristics of a tin roof. Entire lumber yards, freight cars, and even boulders picked up and entrained by high velocity runoff attain momenta which produce the effects of battering rams against densely concentrated structures downstream. In order to obtain maximum benefits from control of this type of flood through operation of a completed flood control system, numerous hypothetical examples of flood routing must be computed by the hydrologist. Observed isohyetal charts of actual storm precipitation are transposed geographically to produce a series of "type floods" which could occur in each of the drainage basins. By routing these hypothetical floods through the reservoir systems, rules for operation of the individual reservoirs under varying conditions are developed with a view to making reservoir operations as foolproof as possible.

The seventh and final characteristic of New England floods is the fact that they are aseasonal in nature. Tropical hurricanes, variable rainfall characteristics, snow and ice melt runoff and winter thaws combine to produce a twelve-month flood cycle for which experience curves indicate damaging floods to be probable any month in the year. In contrast to the Sierra streams like the Truckee River in which spring runoff from snowmelt is an essential component of a damaging flood, in New England the months of January, March, April, August, October, November and December have all witnessed damaging floods of record. Because of their flashiness and unpredicability, operation of the flood control warning system in New England is a "round the clock" twelve months a year business. It is for these reasons that our flood control reservoirs in New England, unlike the general practice at flood control dams anywhere else in America, are cared for by resident damtenders who live permanently at the damsite in order to take advantage of every minute of lag time between heavy precipitation in the controlled area and formation of damaging flood crests.

Finally, the comprehensive flood control plan must meet the demand that benefits to the taxpayer will be greater than the cost of construction. These annual benefits, computed from flood damage reductions in the basin, are compared to the construction cost of the optimum flood control system. This cost, plus interest in the Government's investment and annual operation - maintenance costs, is amortized over the economic life of the structure. The ratio of annual economic benefits to annual costs constitute the "benefit-cost ratio" on which the Corps of Engineers base their recommendations to Congress. A benefit-cost ratio greater than unity is the criterion of a favorable recommendation.

From this summary of the hydrology and economics of New England river basins, one may conclude that some seven distinguishing characteristics of New England river floods combine to differentiate the flood control problem in that area from the problem in other parts of the world. These seven characteristics in combination give rise to a special set of principles on which river flood control planning in New England must be based:

(1) Large dams on main stems are economically prohibitive.

(2) Watershed control must be achieved by numerous reservoirs on the tributaries.

(3) Power and flood control multiple purpose projects are rarely justified.

(4) In each river basin, local protective works must supplement tributary reservoirs to form an integrated system for the basin.

(5) Reservoir systems must be designed to permit particularly precise operation for desynchronization of tributary flow.

(6) The systems must be designed to meet the peculiar prevalence of torrential type floods rather than floods of inundation.

(7) As floods are aseasonal, the flood control and warning systems must operate effectively twelve months a year.

By applying these seven basic principles to the design and construction of flood control works in New England, the Corps of Engineers has formulated comprehensive flood control systems for each of the five major flood-producing basins: the Housatonic-Naugatuck, the Connecticut, the Thames, the Blackstone, and Merrimack River basins. The downstream portions of three of these basin, the Housatonic-Naugatuck, the Connecticut, and the Thames, are the major flood problem areas in the state of Connecticut. In each of these basins a comprehensive system, consisting of a complex of desynchronizing tributary reservoirs and supplemental local protective works, is planned to provide the optimum flood protection that can be economically justified.

NAUGATUCK RIVER BASIN

In August 1955, torrential flooding along the Naugatuck River, the largest tributary of the Housatonic, caused destruction unparalleled by any other flood in the history of New England. The floodwaters of the Naugatuck raged through one of the most densely populated industrial areas in the United States located in the relatively short 41-mile reach of the Naugatuck from its headwaters above Torrington to tidewater in the Derby-Ansonia area. Forty lives were lost and damages exceeded $220 million. Throughout the length of the Naugatuck River an enormous number of industrial, commercial, and residential properties were totally destroyed. Over $136 million of damages were suffered in the short middle reach of the river through Waterbury, Naugatuck and Beacon Falls.

In view of the intensity of the widespread destruction, the Naugatuck Valley was one of the first areas studied by the Corps of Engineers as part of the Northeast Flood Studies program authorized shortly after the flood (Plate 2). From these studies the Corps has thus far developed a comprehensive flood control system of seven reservoirs and three local protective works and preliminary studies of the Ansonia-Derby area have shown that construction of dikes and floodwalls is adequately justified (Table I). Of the six projects currently authorized, one has been completed, two are under construction, and three are under design. Excellent progress is being made on the key unit of this system, the Thomaston dam, which is scheduled for completion in late 1960. When this $30 million system of seven flood control reservoirs and three local protective works has been completed, it will represent one of the soundest flood control investments ever made. The $14 million Thomaston dam alone would have prevented $149 million of the $220 million of damages sustained in the Naugatuck Valley in August 1955. Had the complete system been in operation in 1955, including the four downstream reservoirs on Northfield, Black Rock, Hancock and Hop Brooks which have been recommended for construction, over 90 percent of the total flood damages in August 1955 would have been prevented.

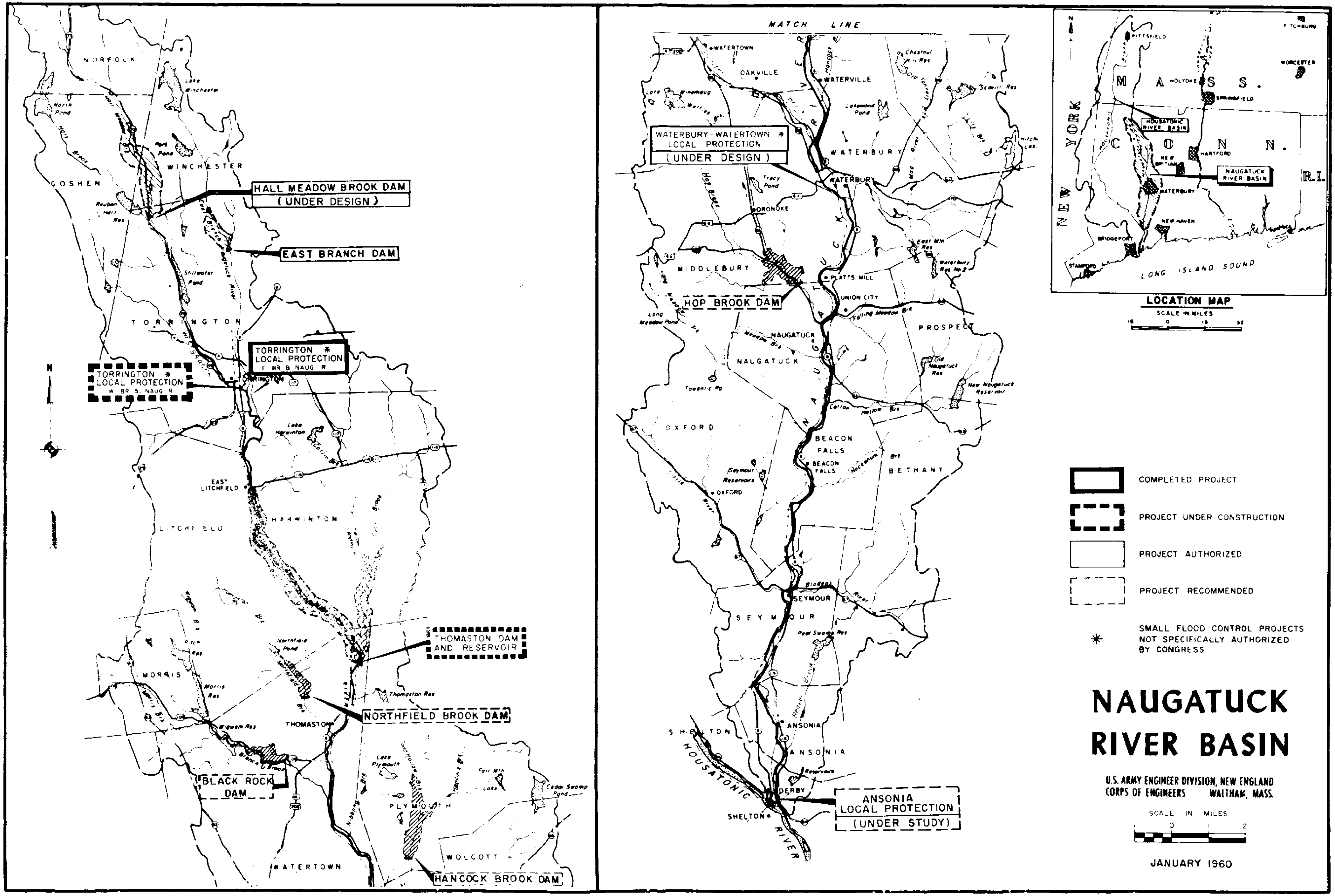

MATCH LINE
HALL MEADOW BROOK DAM
(UNDER DESIGN)
EAST BRANCH DAM
TORRINGTON * LOCAL PROTECTION E. BR. B. NAUG. R.
TORRINGTON * LOCAL PROTECTION W. BR. B. NAUG. R.
THOMASTON DAM AND RESERVOIR
NORTHFIELD BROOK DAM
BLACK ROCK DAM
HANCOCK BROOK DAM
WATERBURY-WATERTOWN * LOCAL PROTECTION
(UNDER DESIGN)
HOP BROOK DAM
ANSONIA LOCAL PROTECTION
(UNDER STUDY)
NORFOLK
WINCHESTER
GOSHEN
TORRINGTON
EAST LITCHFIELD
LITCHFIELD
HARWINTON
MORRIS
THOMASTON
PLYMOUTH
WOLCOTT
WATERTOWN
OAKVILLE
WATERVILLE
WATERBURY
MIDDLEBURY
PLATTS MILL
UNION CITY
PROSPECT
NAUGATUCK
OXFORD
BEACON FALLS
BETHANY
SEYMOUR
SHELTON
ANSONIA
DERBY
HOUSATONIC RIVER
LOCATION MAP
SCALE IN MILES
LONG ISLAND SOUND
NEW YORK
MASS.
CONN.
R.I.
NAUGATUCK RIVER BASIN
HOUSATONIC RIVER BASIN
COMPLETED PROJECT
PROJECT UNDER CONSTRUCTION
PROJECT AUTHORIZED
PROJECT RECOMMENDED
* SMALL FLOOD CONTROL PROJECTS NOT SPECIFICALLY AUTHORIZED BY CONGRESS
NAUGATUCK RIVER BASIN
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.
SCALE IN MILES
JANUARY 1960

PLATE NO. 2

Table I

NAUGATUCK RIVER BASIN

Authorized Program

(All Projects Located in Connecticut)

Name or Location	River	Status	Completion Date
Reservoirs			
Thomaston	Naugatuck	Under Construction	Dec. 1960
Hall Meadow Brook	Hall Meadow Br.	Under Design	June 1962
East Branch	Naugatuck E. Br.	Under Design	--
Local Protection			
Torrington East Br.	Naugatuck E. Br.	Completed	1959
Torrington West Br.	Naugatuck W. Br.	Under Construction	June 1960
Waterbury-Watertown	Naugatuck	Under Design	1960

Future Program

Name or Location	River	Status	Completion Date
Reservoirs			
Northfield Brook	Northfield Br.	Recommended	--
Black Rock	Branch Br.	"	--
Hancock Brook	Hancock Br.	"	--
Hop Brook	Hop Br.	"	--

CONNECTICUT RIVER BASIN

The Connecticut River, the largest in New England, is about 400 miles long and drains approximately 11,200 square miles in four states and Canada (Plate 3). It has minor and sixteen major tributaries, the average draining about 500 square miles.

The flood-producing rainfall of August 1955 affected primarily the southern portion of the basin, causing damages of over $130 million. Although the large population centers of Springfield, Massachusetts and Hartford, Connecticut, protected by dikes and floodwalls, were spared serious damage, heavy damages were suffered along the southern tributaries - the Westfield and Chicopee Rivers in Massachusetts and the Farmington River in Connecticut. Extensive damage took place throughout the Farmington basin, particularly in the western portion in Barkhamsted, New Hartford, Canton and Farmington; but the Mad and Still Rivers, small tributaries of the Farmington, created the greatest havoc, destroying in the Winchester-Winsted area over $30 million of property.

The comprehensive system authorized for the Connecticut River Basin consists of 25 reservoirs and 13 local protection works (Table II). A total of 7 reservoirs and all 13 local protection works

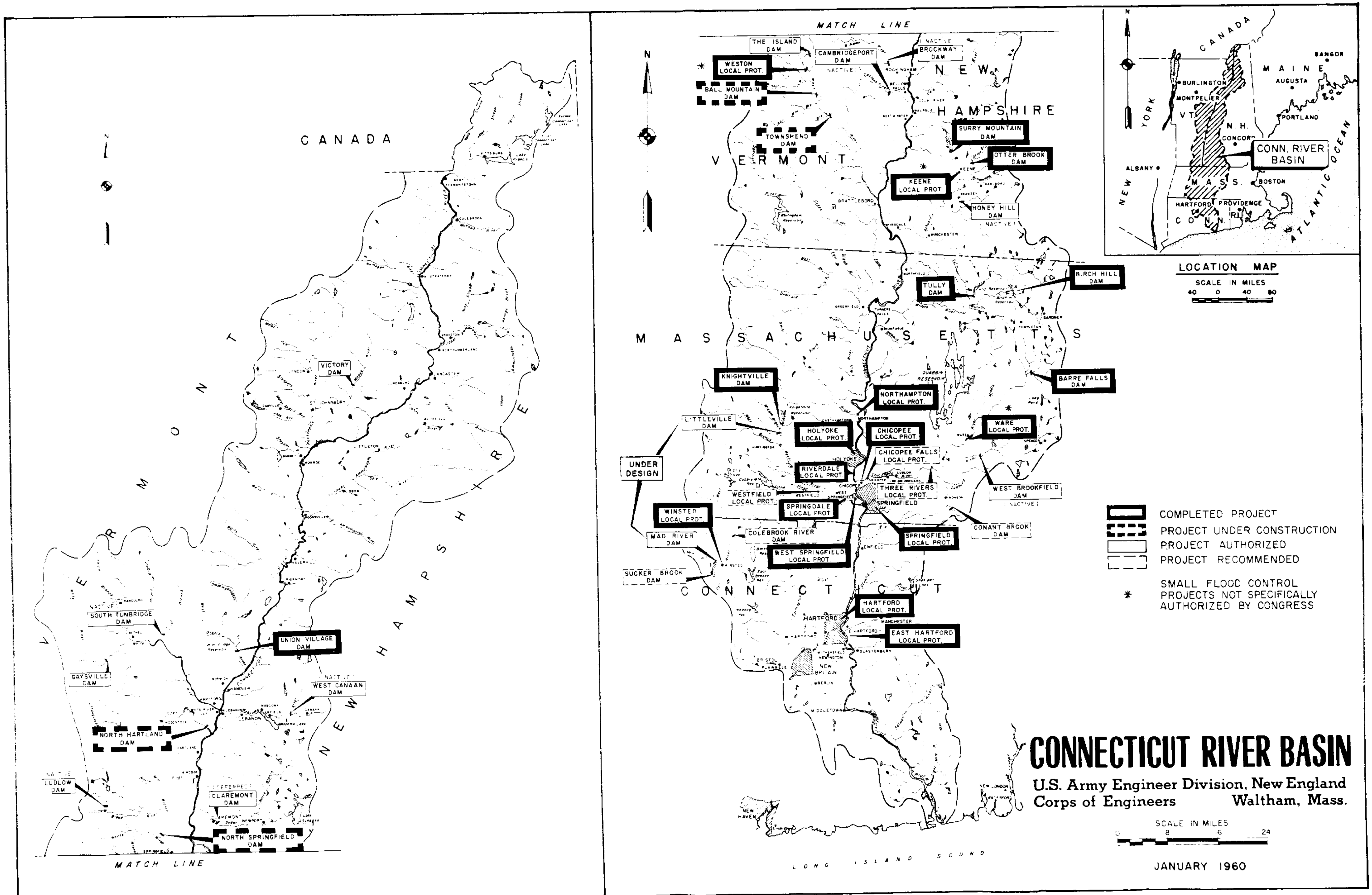

CONNECTICUT RIVER BASIN
U.S. Army Engineer Division, New England
Corps of Engineers
Waltham, Mass.
JANUARY 1960
SCALE IN MILES
MATCH LINE
CANADA
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
CONNECTICUT
LONG ISLAND SOUND
VICTORY DAM
SOUTH TUNBRIDGE DAM
UNION VILLAGE DAM
GAYSVILLE DAM
WEST CANAAN DAM
NORTH HARTLAND DAM
LUDLOW DAM
CLAREMONT DAM
NORTH SPRINGFIELD DAM
THE ISLAND DAM
CAMBRIDGEPORT DAM
BROCKWAY DAM
WESTON LOCAL PROT
BALL MOUNTAIN DAM
TOWNSHEND DAM
SURRY MOUNTAIN DAM
OTTER BROOK DAM
KEENE LOCAL PROT
HONEY HILL DAM
BIRCH HILL DAM
TULLY DAM
BARRE FALLS DAM
KNIGHTVILLE DAM
NORTHAMPTON LOCAL PROT
LITTLEVILLE DAM
HOLYOKE LOCAL PROT
CHICOPEE LOCAL PROT
WARE LOCAL PROT
CHICOPEE FALLS LOCAL PROT.
UNDER DESIGN
RIVERDALE LOCAL PROT
THREE RIVERS LOCAL PROT
WEST BROOKFIELD DAM
WESTFIELD LOCAL PROT.
SPRINGDALE LOCAL PROT
WINSTED LOCAL PROT
COLEBROOK RIVER DAM
MAD RIVER DAM
WEST SPRINGFIELD LOCAL PROT
SPRINGFIELD LOCAL PROT.
CONANT BROOK DAM
SUCKER BROOK DAM
HARTFORD LOCAL PROT.
EAST HARTFORD LOCAL PROT
HARTFORD
SPRINGFIELD
NEW HAVEN
NEW LONDON
LOCATION MAP
SCALE IN MILES
CANADA
MAINE
NEW YORK
N.H.
VT
MASS.
CONN.
R.I.
BURLINGTON
MONTPELIER
CONCORD
ALBANY
BOSTON
HARTFORD
PROVIDENCE
PORTLAND
AUGUSTA
BANGOR
ATLANTIC OCEAN
CONN. RIVER BASIN
COMPLETED PROJECT
PROJECT UNDER CONSTRUCTION
PROJECT AUTHORIZED
PROJECT RECOMMENDED
SMALL FLOOD CONTROL PROJECTS NOT SPECIFICALLY AUTHORIZED BY CONGRESS

PLATE NO. 3

Table II

CONNECTICUT RIVER BASIN

Authorized Program

Reservoirs

Name	River and State	Status	Completion Date
Union Village	Ompompanoosuc, Vt.	Completed	1950
Surry Mountain	Ashuelot, N. H.	"	1942
Birch Hill	Millers, Mass.	"	1942
Tully	Millers (Tully), Mass.	"	1949
Knightville	Westfield, Mass.	"	1941
Barre Falls	Chicopee (Ware), Mass.	"	1958
Otter Brook	Ashuelot (Otter Br.) N. H.	"	1959
North Hartland	Ottauquechee, Vt.	Under Constr.	Dec. 1960
North Springfield	Black, Vt.	"	Dec. 1960
Ball Mountain	West, Vt.	"	June 1961
Townshend	West, Vt.	"	June 1961
Mad River	Farmington (Mad), Conn.	"	Oct. 1963
Littleville	Westfield (Middle Br.), Mass.	Under Design	-
The Island	West, Vt	Active	-
Gaysville	White, Vt.	Active	-
Victory	Passumpsic (Moose), Vt.	Active	-
Claremont	Sugar, N. H.	Deferred	-
Brockway	Williams, Vt.	Inactive	-
Cambridgeport	Saxtons, Vt.	"	-
Ludlow	Black, Vt.	"	-
South Tunbridge	White (First Br.), Vt.	"	-
Honey Hill	Ashuelot (So. Br.) N. H.	"	-
West Canaan	Mascoma, N. H.	"	-
Alternate for Sugar Hill	Ammonoosuc, N. H.	"	-
West Brookfield	Chicopee (Quabaug), Mass.	"	-

Table II (Continued)

CONNECTICUT RIVER BASIN

Authorized Program

Local Protection

Location	River	Status	Date
Northampton, Mass.	Connecticut & Mill	Completed	1941
Holyoke, Mass.	Connecticut	"	1940
Springdale, Mass.	Connecticut	"	1950
Chicopee, Mass.	Connecticut & Chicopee	"	1941
West Springfield, Mass.	Connecticut & Westfield	"	1942
Riverdale, Mass.	Connecticut	"	1950
Springfield, Mass.	Connecticut & Mill	"	1948
East Hartford, Conn.	Connecticut & Hockanum	"	1943
Hartford, Conn.	Connecticut, Park, Gully Br. & Folly Brook	"	1957
Winsted, Conn.	Mad	"	1951
Keene, N. H.	Ashuelot	"	1954
Weston, Vt.	West	"	1957
Ware, Mass.	Ware	"	1959

Future Program

Reservoirs

Colebrook	Farmington, Conn.	Recommended	--
Sucker Brook	Mad River, Conn.	"	--
Conant Brook	Chicopee, Mass.	"	--

Local Protection

Three Rivers	Chicopee, Mass.	"	--
Chicopee Falls	" "	"	--
Westfield	Westfield, Mass.	"	--

have been completed and put into operation at a Federal cost of $40.7 million. The Knightville, Birch Hill, Tully, Surry Mountain, Union Village, Barre Falls, and Otter Brook reservoirs control several of the most damaging of the Connecticut River tributaries, and the series of dikes and floodwalls along the river at Northampton, Holyoke, Chicopee, and Springfield, Massachusetts, and at Hartford, Connecticut, shield these local damage centers.

Six reservoirs estimated to cost $42 million are in advance design or under construction, including the $6,000,000 Mad River reservoir now under construction to protect Winsted, Connecticut. Construction of three additional authorized reservoirs for control of the Passumpsic, White and West Rivers in Vermont appears justified under present economic conditions. Economic changes in the basin since the remaining nine reservoirs were planned will require re-evaluation of these projects.

Typical of the methods used to formulate the flood control systems in each of the New England's flood-producing basins, the development of the integrated flood control system presently authorized for the Connecticut Basin was based on hydraulic analyses of experienced floods and damage surveys. Possible local protection works at damage centers were studied and several hundred dam sites were investigated. The most economical method of flood control appeared to combine tributary reservoirs and local works on the main stem since reservoirs alone would not reduce flood stages sufficiently at the main-stem damage centers, and dikes or floodwalls designed to contain unreduced stages would require impractical heights and great costs.

The present estimate of the flood-producing potential of the Connecticut River Basin was computed from the flood records of March 1936, September 1938, June 1947, January 1949, and the August and October floods of 1955. The Connecticut River was divided into successive reaches limited by the mouths of tributaries and hydraulic control points. Both observed and synthetic hydrographs of these reaches with allowances for distance of travel, character of reach, amount of intervening inflow, and relative timing were routed downstream to determine their contributions to main river peaks. This analysis revealed that major floods in the lower basin originated in tributaries of the lower 266 miles of the river. These 14 flood-producing tributaries, in downstream order, are:

1. White River, Vt.
2. Ottauquechee River, Vt.
3. Sugar River, N.H.
4. Black River, Vt.
5. Williams River, Vt.
6. Saxtons River, Vt.
7. Cold River, N.H.
8. West River, Vt.
9. Ashuelot River, N.H.
10. Millers River, Mass.
11. Deerfield River, Vt. & Mass.
12. Chicopee River, Mass.
13. Westfield River, Mass.
14. Farmington River, Mass. and Conn.

The discharges of the tributaries to the central Connecticut River Basin are closely synchronized and combine to produce the major flood crest in that area (Plate 4).

Studies of great storms in the Connecticut River Basin indicate the probability of a flood somewhat greater than the record flood of March 1936. Protective works must therefore be based on this greater flood. Depth and distribution of rainfall were studied to determine the "Standard Project Storm". The "Standard Project Flood" was computed from this hypothetical "standard" storm by means of mass rainfall curves of the tributary areas, unit hydrographs and flood routings from river channel characteristics of past floods. This Standard Project Flood, combined with the major floods of record, determined the flood control system finally recommended to Congress.

An analysis of the flood of August 1955 indicated the need for additional reservoirs in the lower valley tributaries. The grade of the dikes and floodwalls along the main river is designed for a flood somewhat greater than that of March 1936 - after reduction by the authorized system of reservoirs. As long as this upstream reservoir system remains incomplete, these dikes are in danger of failure. Hurricane "Diane" of 1955, for example, would have caused a flood much greater than that of 1936 had it continued up the Connecticut Valley instead of curving out to sea over eastern Massachusetts.

TRIBUTARY CONTRIBUTIONS TO FLOOD PEAK ON CONNECTICUT RIVER AT HARTFORD, CONN.

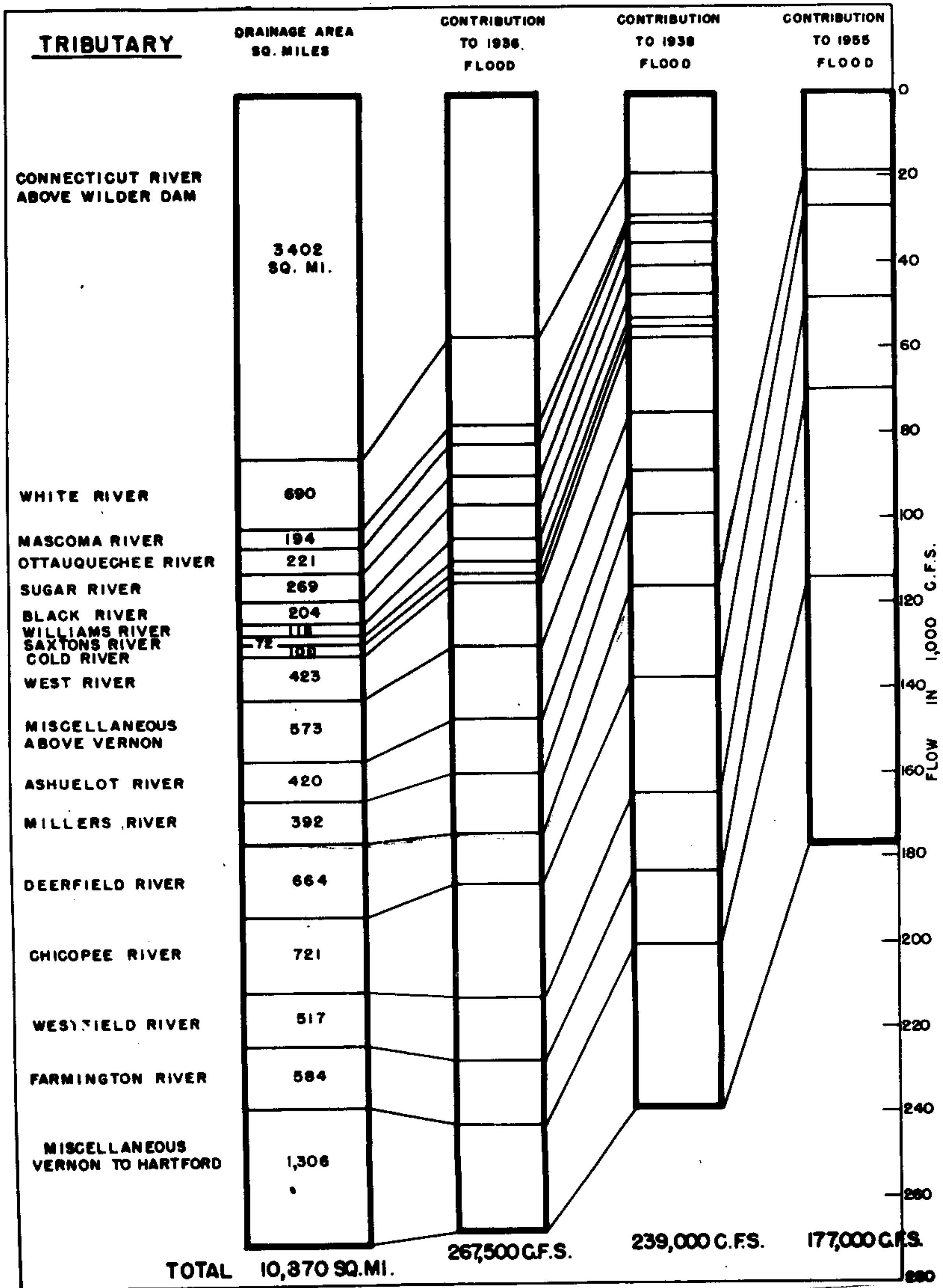


PLATE NO. 4

The seven existing flood control reservoirs and the five now under construction on the West, Ottauquechee, and Black Rivers in Vermont, the Ashuelot River in New Hampshire and Chicopee River in Massachusetts will reduce both main river flood peaks and tributary damage. The Littleville Reservoir in Massachusetts, and Mad River Reservoir in Connecticut will increase control over the southern tributaries. The systematic review of all rivers in the Northeast now underway has led to recommendation of the Conant Brook reservoir and three local protective works in the Massachusetts portion of the Connecticut River basin as well as two more reservoirs in the Farmington Basin in Connecticut, the Colebrook and Sucker Brook reservoirs. The Colebrook reservoir is the first flood control project to incorporate provisions for water supply under the authority of the Water Supply Act of 1958, and this report will be a model for future studies of reservoirs in the United States combining flood control and water supply. These new projects, although representing considerable progress, will greatly ameliorate but will not completely solve the problem of flood control in the Connecticut River basin.

Cumulative benefits of the 7 reservoirs and 13 local works built at a federal cost of approximately $40 million between 1936 and 1959 have amounted to over $85 million. Several of the projects built prior to 1955 have paid for themselves many times over. Knightville Reservoir, for instance, built at a cost of $3,216,500 prevented damages of $6,480,000 during the flood of August 1955 alone.

THAMES RIVER BASIN

A long history of flooding in the Thames River Basin, climaxed by the major floods of 1936 and 1938, led to authorization in the Flood Control Act of 1941 of a comprehensive flood control system for the Thames River Basin consisting of seven reservoirs and one local protection project (Table III). The current estimate of the cost of this system is $43.5 million.

Prior to the flood of August 1955 only two units of this plan had been completed, the Mansfield Hollow Reservoir on the Natchaug River and part of the Norwalk Channel Improvement in the Thames River (Plate 5). Although these completed projects effectively reduced damages in this area -- Mansfield Hollow prevented over $3,000,000 of damages -- the August 1955 flood caused $60 million of damages throughout the Thames River Basin, nearly half of which was sustained in the Connecticut portion of the basin. Under the accelerated program of flood control set in motion by the August 1955 flood, four additional reservoirs have been undertaken in the Quinebaug-French River system, the major tributaries of the Thames River. The Buffumville Reservoir on the Little River, a heavy contributor to flooding on the French River, was completed and put into operation in 1958. Three more units of this system, the Hodges Village,

Table III

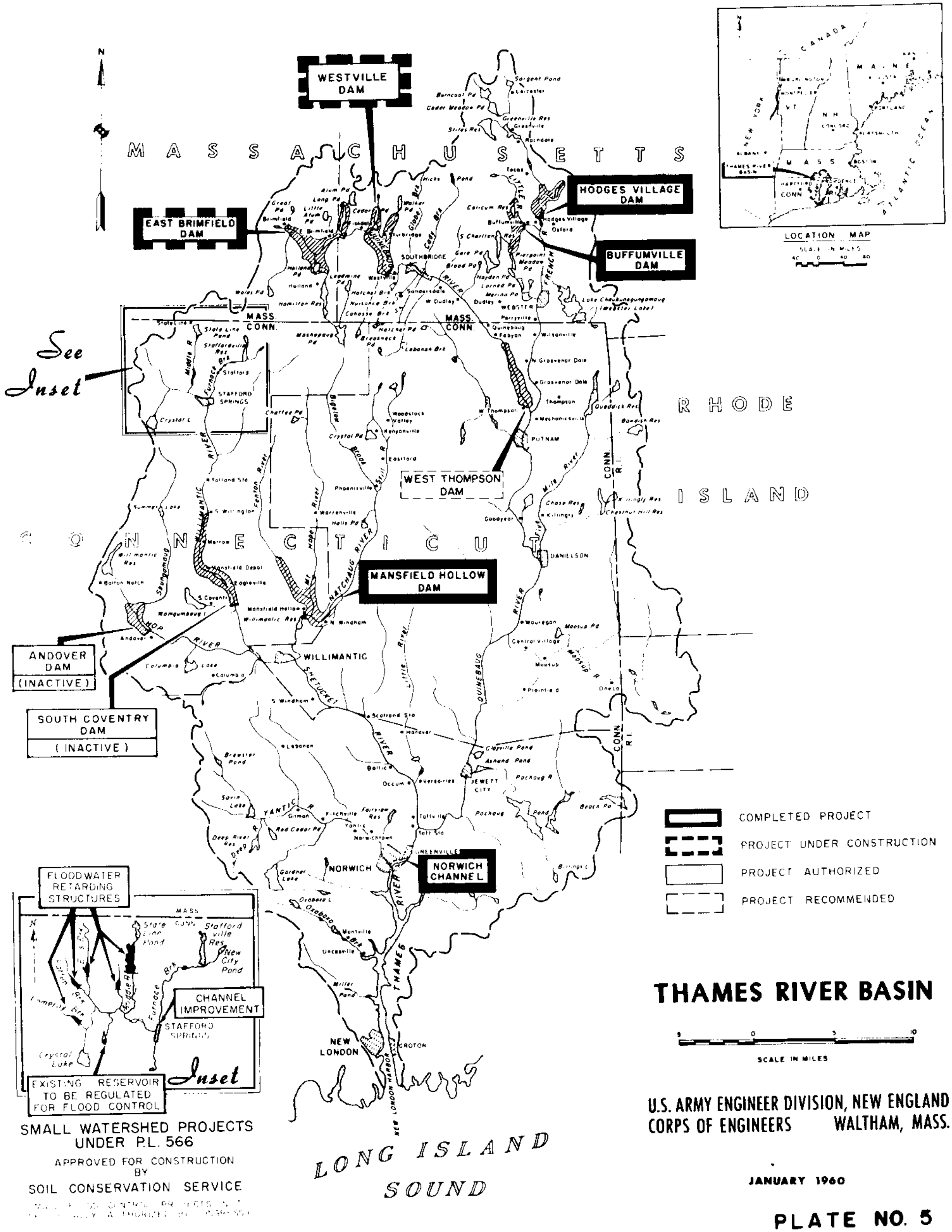
THAMES RIVER BASIN

Authorized Program

Name or Location	River and State	Status	Completion Date
Mansfield Hollow Res.	Natchaug, Conn.	Completed	1952
Buffumville Res.	Little, Mass.	Completed	1958
Hodges Village Res.	French, Mass.	Under Construction	June 1960
East Brimfield Res.	Quinebaug, Mass.	Under Construction	June 1960
Westville Res.	Quinebaug, Mass.	Under Construction	Feb 1962
Andover Res.	Hop, Conn.	Inactive	--
South Coventry Res.	Willimantic, Conn.	Inactive	--
Norwich Local Protection	Shetucket, Conn.	Completed	1958

Future Program

West Thompson Res.	Quinebaug, Conn.	Recommended	--



THAMES RIVER BASIN

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.

JANUARY 1960

PLATE NO. 5

East Brimfield, and Westville dams are now under construction, and the former two dams are rapidly approaching completion.

The ninth unit of Thames flood control system, the West Thompson dam and reservoir, has been recommended to Congress for authorization. This reservoir, located on the Quinebaug River two miles upstream from Putnam, Connecticut, will considerably increase the control of flood flows through the central and lower portions of the Quinebaug River and provide a high degree of protection to Putnam and other downstream communities in Connecticut. Had this system of nine projects been in operation during the flood of August 1955, $43 million of the $55 million of property lost in the French-Quinebaug area of Thames Basin would have been prevented.

The Andover and South Coventry dams now classed as inactive, were planned after the 1938 flood to operate in conjunction with the Mansfield Hollow reservoir and thus bring a greater percentage of the Willimantic-Shetucket watershed in Connecticut under control. In the intervening years, these plans have been overtaken by events, and rapid development within the reservoir areas have made acquisition of land for these reservoirs today prohibitively costly. As part of the comprehensive review of flood control planning now underway, more economical sites are now being investigated to attain an adequate degree of flood control in this portion of the Thames River Basin.

In conclusion, the Corps of Engineers has investigated all possible methods of flood control to protect the people and economy of New England from ever-increasing flood damage. Experience has shown that practical control of flood-producing rivers and streams usually demands a combination of several methods. The most effective method is a comprehensive system of upstream tributary reservoirs operating in conjunction with local protective projects constructed through highly developed downstream areas along the main stems of rivers. The upstream reservoirs temporarily impound flood waters on tributary streams to effectively desynchronize contributions to the flood peaks on the main rivers, and local protective projects allow these reduced flows to pass safely downstream in ways and places least harmful by diverting the stream or by increasing the capacity of a river to carry flows -- accomplished by creating artificial banks with levees, dikes or floodwalls, or by enlarging natural channel capacities.

Two additional elements of flood control planning should be considered. Watershed treatment, or "land management programs," and flood plain zoning, both of which play significant roles in other parts of the country, contribute only minimally to flood control in New England. Soil conservation through contour plowing, reforestation, and other methods of land management for the control of erosion and watershed runoff have a beneficial effect on minor floods. These measures have little effect, however, on major floods. Great floods occurred as early as 1635, 1683, and 1692, when New England was a virgin wilderness and land management problems were of little consequence.

Flood-plain zoning is, of course, the only positive means of preventing damage. Since all uncontrolled rivers inundate their flood plains periodically, man takes a calculated risk when he builds homes and factories along the banks of streams. The more he builds and encroaches upon the flood plain, the greater the risk of flood damage. Nevertheless, this risk has long been accepted in New England and under present conditions of development, the cost of flood-plain zoning would involve a major relocation of the industry and population of the region. Recent public awareness of the flood potential of New England streams is evident, however, in the efforts of the state planning commissions and urban development groups to encourage new industry and housing developments to seek higher ground. In view of the remarkable progress made in the flood control program in Connecticut during the past five years by the local, state and federal governments, it is not unusual that Connecticut has taken the lead as one of the first states in the nation to legislate control of encroachments on rivers and streams with high flood potential.

On the basis of per capita expenditures made by the federal government to control the state's major flood-producing rivers, Connecticut now ranks third in the nation. This fine progress has been made possible by the invaluable cooperation and support of the people of Connecticut, and the U. S. Army Corps of Engineers is proud to join with them to protect the people of New England from the ravages of nature just as it stands ready to defend them in war.